

GRAPHICAL USER INTERFACE FOR AUTOMATED PROCESS CONTROL

CROSS-REFERENCES TO RELATED APPLICATIONS

5 The present application is a continuation-in-part of U.S. patent application 09/930,698, Ran J. Flam, *System and method for automated process control*, filed 8/15/2001, which in turn claims priority from U.S. provisional application 60/225,532, Ran J. Flam, *System and method for automated process scheduling*, filed 8/16/2000. The CIP contains the entire *Detailed Description* of USSN 09/930,698; the material added in the CIP includes material in the section *Details of*
10 *administrative query execution* and all of the material in the sections beginning with the section *Details of the GUI for defining and modifying administrative queries*.

FIELD OF THE INVENTION

15 This invention relates to the field of process control, and more particularly to techniques for using a database system to implement a table-driven process control system.

BACKGROUND OF THE INVENTION

20 To date, the use of computers in process control systems has typically been limited to employing a calendar-date activation system that reminds the operator when an activity is due to be performed. Conventional process control systems suffer from a major drawback. Typically, they rely on a singular input, such as calendar date and time, and require human interaction to respond to such events and their recurrence and to make decisions and take action
25 accordingly; an example of such a system is Outlook, manufactured by Microsoft Corporation, with its reminder capability.

Other systems have filters which can account for a given set of conditions and take actions accordingly; an example of such a system is the AR System by Remedy Corporation. Even though that system can monitor for multiple pre-
30 defined conditions in the process and can schedule the monitoring and any actions taken in response to the monitoring, the scheduling is limited to scheduling a single occurrence of the monitoring and the associated actions at a predetermined date or time or at a recurring fixed time interval. Furthermore, although this system has the ability to detect a recurring match of a given set of
35 conditions so that additional, and possibly different, actions can be taken based on a time interval, as is required when a problem persists and must be escalated, the users can neither configure the time intervals nor the actions themselves; rather they can only select from a fixed set of component choices. The

rather they can only select from a fixed set of component choices. The components themselves are not user-definable, and therefore limit the extensibility of the escalation functionality.

Available systems are further limited to doing their monitoring at
5 infrequent intervals, since the monitor always has the same response to a given condition. If the monitoring is done frequently, say every 10 minutes, the result is a flood of redundant responsive actions unless the output of responsive actions is simply curtailed after a fixed number has been sent over a given period of time. Neither infrequent monitoring nor ignoring the monitoring is conducive to
10 the timely detection of events and conditions in a process that is being controlled.

Moreover, existing systems lack the ability to perform responsive actions based on an overall count of process records matching a given set of conditions, and beyond that, they lack the ability to respond to trends over time with regard to such counts. Existing systems are therefore unable to provide proactive
15 responses that can eliminate the need to take corrective actions.

Although computer programs can always be developed to implement responses to specific conditions arising during a process and to particular sequences of conditions, such programs are of limited use, as they require code changes whenever new conditions and new requirements arise. Moreover,
20 program code is by its nature general, and user-made modifications to a process control system's code can have consequences for the system that go far beyond what the user intended.

Because of these deficiencies, there are presently no process control systems available that are able to control processes that require many different
25 process-related criteria to be continuously monitored and actions taken in response thereto at pre-determined times and time intervals and where the conditions justifying a certain action may vary substantially from one process to another, as may the need to respond to a persistent set of conditions. Moreover, such process control systems as have been devised to monitor complex processes
30 are not easily or safely configurable or modifiable by their users.

It is therefore an object of the present invention to overcome the above described deficiencies: to eliminate the dependency of such systems on human operators; to allow frequent monitoring of conditions and selective execution of responsive actions to occur at predetermined times and time intervals; to provide
35 timely responses; to automatically detect states of persistent conditions and execute different actions as needed, based on the recurrence of given conditions, and based on elapsed time between responsive actions; to provide the ability to take responsive actions based on trends, so that such actions are proactive, rather than reactive; and finally, to configure a system that performs such monitoring
40 and executes responsive actions in a safe and user-friendly manner and thereby

reducing the need to use skilled people to adjust a process control system to evolving needs in a timely way.

SUMMARY OF THE INVENTION

One of the major contributors to achieving the foregoing object of the invention is the graphical user interface that system 801 uses to define and modify administrative queries, and in particular the graphical user interface that system 801 uses to define and modify the actions performed by an administrative activity. This graphical user interface is a window which contains a table that in turn contains an entry for the field in the PR record upon which the action is to be performed when the PR record is returned by an administrative query. The entry includes a first field which identifies the field in the PR record to be acted on and one or more action fields that, when the user has selected the entry, the user may set to specify the action.

In other aspects of the invention, there is a window for each of the kinds of actions that may be performed by an administrative activity, and the kind of action determines what action fields are in an entry for a field. One kind of action that may be defined is setting, clearing, or incrementing a field. Values of fields that may be incremented must belong to an ordered set of values. What an action does may further depend on whether the field to which it is applied has a null value or another value.

An action may also obtain a value for the field to which the action is applied from another field in the PR record. This other field is termed a *reference* field. The action may simply assign the reference field's value at the time the action is performed to the field to which the action is applied or it may modify the value before assigning it. In the case of actions on fields with time values, the modification may increase or decrease the time value obtained from the reference field, may specify the kind of time units to use, and when the units are days, may specify whether the computation is to use calendar days or business days.

When the action is on a field that takes a person value, the value may be set from a *role* field. The role field provides a person value from an ordered set of person values; state associated with the role field specifies the last value provided, and the role field provides the next value in the ordered set to the field the action is on.

The foregoing and other objects and advantages of the invention will be apparent to those skilled in the arts to which the invention pertains upon perusal of the following *Detailed Description* and drawing, wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a flowchart depicting the steps by which an exemplary
5 embodiment of the present invention operates.

FIG. 2 shows a flowchart depicting how administrative activities are
configured in an exemplary embodiment of the present invention.

FIG. 3 shows a flowchart depicting how administrative queries are
configured in an exemplary embodiment of the present invention.

10 FIG. 4 shows a flowchart depicting the steps by which an exemplary
embodiment of the present invention executes administrative queries.

FIG. 5 shows a flowchart depicting the steps by which an exemplary
embodiment of the present invention processes a result set.

15 FIG. 6 is a first entity-relation diagram showing relationships between
database tables in the present invention.

FIG. 7 is a second entity-relation diagram showing relationships between
database tables in the present invention.

FIG. 8 is an overview of an implementation of the process control system
of the present invention.

20 FIG. 9 shows the top-level window used to make or modify an
administrative query.

FIG. 10 shows windows used to specify an administrative query's scope.

FIG. 11 shows windows used to schedule an administrative query.

25 FIG. 12 shows the window used to define or modify an administrative
query's administrative activity.

FIG. 13 shows windows used to define an AA_set_values action.

FIG. 14 shows windows used to define an AA_set_dates action.

FIG. 15 shows windows used to define an AA_set_person action.

FIG. 16 shows windows used to define an AA_post_activities action.

30 FIG. 17 shows windows used to define an administrative query.

In the following discussion, reference numbers are used to refer to
components of the invention. Each reference number has two parts: the

rightmost two digits are a number within a figure; the remaining digits are a figure number. The figure number is the number of the figure in which the component first appears. Thus, the first appearance of a component with the reference number 203 will be in FIG. 2

5

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The following *Detailed Description* will begin with an overview of a process control system in which the invention is embodied, continue with a detailed description of the tables belonging to the process control system and the relationships between them, thereupon provide a detailed description of the operation of the process control system, and will finally describe the graphical user interface of the invention.

Overview of the process control system in which the invention is embodied--FIG. 8

FIG. 8 shows an overview of an embodiment of automated process control system 801 that is constructed according to the principles of the invention. The embodiment is used to control business processes such as handling orders or customer complaints, but the techniques of the invention can be employed equally well in systems that control industrial or technical processes such as oil refining, electric power generation, or telephone or packet switching.

System 801 is implemented using a standard computer 803 that is connected to a standard database system 825. In a preferred embodiment, the database system is a relational database system made by Oracle Corporation, of Redwood City, California. Standard computer 803 has a processor 805 which is connected to Internet 807 and to local peripheral devices 808 as well as to database system 825. Processor 805 has a memory 809 (understood to include both physical and virtual memory) which includes code executed by processor 809. Of interest to the present discussion is standard operating system code 811, Internet code 815, for performing functions such as email and interacting with Web pages according to the HTTP protocol, Database code 813, which is part of and controls the operation of database system 825, and process control code 817, which is application code that implements the process control system. Process control code 817 uses components of the operating system 811, Internet code 815, and DB code 813 to interact with Internet 807, local peripheral devices 808, and DB system 825. With regard to the interaction with DB system 825, process control code 817 issues queries to DB system 825 and receives the results of the queries from DB system 825.

In broad terms, process control system 801 works by making records of processes that are being controlled in a table in database system 825 and using predefined queries that are stored in a table database system 825 to repeatedly query the table and perform activities that are predefined for the query on the result set of records returned by the query. The repeated queries are executed automatically by system 801. The predefined and automatically executed queries are termed herein *administrative queries*. An activity is made up of a number of predefined *actions*, and when the activity is performed, system 801 executes its actions. The activities to be performed by an administrative query, as well as an activity's actions, are also defined by entries in tables in the database system, and log tables in the database system determine the state of a process record returned by the administrative query with regard to that execution of the administrative query. When an execution of a query returns a process record, system 801 uses the state information to determine what activity is to be performed with regard to the process record.

Current schedule table 823 in memory 809 contains an entry for each administrative query which system 801 is repeatedly executing; the entry for the query in table 823 includes the time for the next execution of the query by system 801. Current query and processing plans table 824 is an optimization; when system 801 begins execution of an administrative query, it reads the information needed to execute the administrative query and perform any activities associated with it from the records in database system 825 that define the query and the activities and stores the information in table 824, where it is quickly and easily available to system 801 for use during the execution of the administrative query. Tables 823 and 824 are updated whenever system 801 checks database system 825 and finds that configuration tables have changed; such update of table 823 and 824 is then performed based on the configuration information fetched from database system 825.

As would be expected from the above overview, database system 825 includes PR tables 827, which are the tables that contain the records for the processes, PR activity tables 835, containing records that define and log the activities, action tables 857, whose records define the actions that make up an activity, and administrative query tables 845, which define the administrative queries that system 801 may execute on the PR tables 827. The definition of an administrative query includes the query, one or more activities to be performed, and the intervals at which the administrative query is to be made. Log tables 871 keep track of the state of a process with regard to a query and also chart trends in the processes being controlled. Log tables 871 and program sequence 855 together permit the activity that is performed when a query finds a PR record to be selected according to the state of the PR record with regard to the current execution of the administrative query.

To give a concrete example, one type of process that can be controlled by system 801 is a customer complaint. The exemplary process for dealing with a customer complaint is to assign it to a customer complaint specialist. The customer complaint specialist is to investigate the complaint and reply to the customer within a set time period. If the reply is not timely, the complaint is escalated to the customer complaint specialist's supervisor, again with a time limit for the supervisor to deal with the problem. The activity that corresponds to the escalation is the dispatch of an email message to the supervisor. In system 801, when the complaint arrives, a PR record for the complaint is made in a table in PR tables 827. When the complaint specialist replies to the customer, the PR record is altered to indicate that the complaint specialist has replied and the time of the reply. System 801 periodically runs a query contained in administrative query tables 845 which queries PR table 833 for PR records that indicate that the complaint specialist has not timely replied. The query further specifies that when the complaint specialist has not timely replied, the activity to be performed is to escalate the complaint by sending email to the supervisor. When system 801 finds such a record, it performs the specified activity, as defined by records in PR activity tables 835 and in action tables 857. System 801 records the time at which the query was run, the fact that the PR record was found and the activity performed in log tables 871. As will be explained in detail later, one function of log tables 871 is to record the state of a process with regard to a given PR record and a given execution of a query and to permit different executions of the given query to result in different activities being performed for the given PR record, depending on the state of the process. For instance, once the escalation is recorded in the log tables with regard to the query and the PR record, further executions of the query will not result in repeated escalation activities. In the terminology that is used in the following, once the query has resulted in the performance of the escalation activity for the given PR record, the given PR record is in a state of Persistent Conditions with regard to the query and because the given PR record is in the state of Persistent Conditions, the escalation activity is not repeated.

The use of tables in DB system 825 to determine the behavior of the process control system makes system 801 highly configurable, but limits the configurability so that it can be safely done by non-technical users of system 801. All of the tools provided by DB system 825 for configuring entries in its tables are available to configure the entries in the tables of system 825, as are the user interfaces which DB system 825 provides for those tools. These user interfaces strongly limit the amount of damage that can be done to the tables, and thereby to system 801, by an unskilled user. For example, only a system manager may be permitted to define tables or add tables to or delete them from the database; a less skilled user may be permitted only to add or delete records in existing tables, and a completely unskilled user may be permitted only to modify fields in existing records. System 801 is made still more safe and easy to use by a

graphical user interface that is implemented on top of the user interfaces provided by DB system 825. Using the graphical user interface, the user of the system can define PR records as required for the occurrences that are important to his or her processes, can define his or her own PR activities in PR activity tables 835, can define his or her own queries in administrative query tables 845, including the activities to be performed in response to the queries, and can define an activity's actions in detail in action tables 857. What can be done by a given action is limited by the form of its record in the action table to which it belongs, and this, too, greatly contributes to the safety with which system administrative queries can be configured. In defining the activities to be performed, the user can further define states for the process represented by the record and the activities to be performed in the various states. Both configuration and query execution are done by process control code 817, which accordingly includes an execution module 821, which executes queries and schedules next executions in current schedule table 823 and an admin module 819, which adds records to and deletes them from the tables and configures the individual records. System 801 can run on a single computer 803, which functions as a server for the system, or alternatively it can run concurrently on a plurality of servers for load balancing purposes.

Relationships between the tables in DB system 825: FIGs. 6 and 7

FIGs 6 and 7 are entity-relationship diagrams which show relationships between the database tables of system 601 which are important in the present context. In relational database systems generally, tables are related to each other by values in the tables' records. For example, each record in a first table may have a record identifier field that contains a unique identifier for the record. Each record in a second table may have a record reference field that contains a value which is one of the unique identifiers for the records in the first table. The unique identifier for a given record in the first table may be used in a query to locate records in the second table whose record reference field contains the given record. Similarly, the value of the record reference field may be used in a query to locate the record in the first table whose record identifier field has the value contained in the record reference field in the second table's record. It should be noted here that the relationships between records in tables may be one-to-many, as in the case of the relationship between a given record in the first table and the records in the second table whose record reference field contains the given record's unique identifier, or one-to-one, as is the relationship established by the unique identifier value between a given record in the second table and a record in the first table.

In FIGs. 6 and 7, boxes representing the tables of FIG. 8 are connected by arrows that are labeled with the name of a field whose value is a unique identifier for a record in the table which is the source of the arrow. Values from

that field also appear in the records of the table which is the destination of the arrow and relate those records to the record whose unique identifier they contain. The relationship between a record in the table which is the source of the arrow and records in the table which is the destination is generally one-to-many, but is in some cases one-to-one.

These relationships between records in the tables are used to organize the data in the database. For example, in system 801, the records representing processes that are being controlled by system 801 are in PR table 833, which contains one record per process being controlled. In system 801, the user can group the records in PR 833 by project, and can group projects by division. The subdivision is done by means of Project table 831 and Division table 829. Each record in PR table 833 has a field, *project_id*, whose value is an identifier for a record in Project table 831, and that record identifies the project that the record in PR table 833 belongs to. Each record in Project table 831 has a field, *division_id* 603, whose value identifies a record in Division table 829, and that record identifies the division that the record in Project table 831 belongs to. A query on PR table 833 by a given value of *project_id* 605 will return all of the records in PR table 833 for processes that belong to that project. Project table 831 and Division table 829 are related in the same way by *division_id* 603.

A set of relationships that is particularly important for the present discussion is the set of relationships between the tables PR 833, PR_activity 839, PR_activity_type 837, Admin_activity_type 841, Action tables 857, Admin_query 853, and Program_sequence 855. All of these tables have to do with the performance of activities for processes. There are two broad classes of activities--ones done by human users of system 801 and ones done by system 801 itself in connection with executions of administrative queries on PR table 833 that return non-empty result sets. The latter activities are termed *administrative activities*. The administrative activities are performed with reference to the PR records of the result sets. In the present context, we are primarily concerned with administrative activities.

An important feature of system 801 is that a user can define his or her own activities. The mechanism for doing this is PR_activity_type table 837, whose records represent descriptions of activities. Each such description is termed herein a *PR activity type*. Fields in other tables of FIGs. 6 and 7 whose values are identifiers for PR_activity_type records have the name *pr_activity_type*, which appears at 609 in FIGs. 6 and 7. The PR_activity_type records that represent descriptions of administrative activities form a logical subtable of PR_activity_type table 837. This subtable appears as Admin_activity_type table 841 in FIGs. 6-8. In the following, the descriptions in subtable 841 are termed herein *Admin activity types*.

An Admin activity type is effectively a kind of program for the administrative activity. When system 801 performs an administrative activity, it executes the Admin activity type for the administrative activity with regard to a specific PR record returned by an execution of an administrative query. One can thus speak of an *execution* of an Admin activity type with regard to a given PR record. As is generally the case with programs, the specific activity resulting from a given execution of an Admin activity type may depend not only on the Admin activity type, but also on values contained in the PR record with regard to which the Admin activity type is being executed. Which Admin activity type is selected for execution may further depend on the state of the given PR record with regard to the execution of the administrative query.

When system 801 executes an Admin activity type, it performs one or more actions. Each of the actions is described in a record in action tables 857. Each record in action tables 857 is related to a specific Admin activity type by a field in the action table record whose value is the identifier for the Admin activity type's record in PR_activity_type table 841, as seen in FIG. 6. There can thus be many records in action tables 815 related to a given Administrative activity type. When the Administrative activity type is executed, all of the action table records related to the Administrative activity type are executed. The result of the execution of a given action table record may depend on values in the PR record with regard to which the Admin activity type is being executed.

PR_activity table 839, finally, is a table whose records represent activities that have been performed or are scheduled to be performed with regard to a given PR record. Thus, as shown in FIG. 6, each PR_activity record includes a unique identifier (pr_id 607) for a record in PR 833 and a unique identifier (pr_activity_type 609) for the record in PR_activity_type table 837 that represents the PR activity type for the activity represented by the record. In the case of administrative activities, the record in PR_activity table 839 represents the activity which system 801 performs when it executes the Admin activity type specified by pr_activity_type 609 on the PR record specified by pr_id 607.

As shown in FIG. 6, each record representing an administrative query in Admin_query table 853 includes a unique identifier for a record in PR_activity_type table 837. The record is the Admin activity type which system 801 executes the first time the administrative query returns a given PR record to perform the initial administrative activity. It has already been indicated that when consecutive executions of the administrative query return the given PR record, the given PR record is in a state of Persistent Conditions with regard to the administrative query and on subsequent executions of the administrative query, system 801 may perform administrative activities other than the initial administrative activity with regard to the PR record. Administrative activity types for these other administrative activities are specified in records in Program_sequence table 855 that are associated with the administrative query,

and accordingly, each of these records includes a unique identifier for a record in PR_activity_type table 853.

Details of PR tables 827

- 5 As already explained, there is a record in PR table 833 for each process being controlled by system 801, and Project table 831 and Division table 829 organize the PR table records by project and the projects by divisions.

PR table 833

- 10 A record in PR table 833 looks like this:

```

PR (
    id                NUMBER(12) NOT NULL,
    project_id        NUMBER(12),
    ref_number        VARCHAR2(40),
    name              VARCHAR2(80),
    parent_id         NUMBER(12),
    status_type       NUMBER(6),
    category_type     NUMBER(6),
    reason_opened_type NUMBER(6),
    priority_type     NUMBER(6),
    severity_type     NUMBER(6),
    exposure_type     NUMBER(6),
    entity_id         NUMBER(12),
    customer_rel_id   NUMBER(12),
    originator_rel_id NUMBER(12),
    responsible_rel_id NUMBER(12),
    required_time     NUMBER(10,2),
    required_cost     NUMBER(12,2),
    date_opened       DATE,
    date_due          DATE,
    date_closed       DATE,
    date_last_activity DATE,
    date_current_state DATE,
    is_closed         NUMBER(1),
    date_created      DATE NOT NULL,
    date_updated      DATE NOT NULL,
    created_by_rel_id NUMBER(12),
    updated_by_rel_id NUMBER(12),
    primary key(id)
)
```

- 45 PR table 833 contains all process records (PR records) in the database. The data fields in this table describe a process and contain such information as priority, customer and date due. A first group of the fields must appear in every PR record; other fields may be added as required by the application. The other

fields in the present example offer a typical example of how a PR record may be configured.

Essential fields

5 The essential fields of a PR record are: (a) id: a unique ID for the record in this table, referred to in FIGs. 6 and 7 as pr_id 607, (b) project_id: the ID of the record in Project table 833 for the project that the project represented by the given PR record belongs to, (c) date_created: the exact date/time that a given PR is created, i.e., that the given row into the PR has been inserted, (d) date_opened:
10 the date/time that the associated process, event, etc. should be associated with, e.g., the date/time that a customer called with a request, (e) parent_id: the ID of a parent PR, if any, (f) status_type: current status of the PR, e.g., "Opened", and "Work in Progress", (g) is_closed: a Boolean value indicating whether a PR is closed or is still active, (h) date_due: the date due for completing a process, i.e.,
15 date due for closing a PR, (i) created_by_rel_id: a specific ID of a person who created the given PR record in the database, (j) originator_rel_id: a specific ID of a person who is considered the originator or the "sponsor" of the given PR, (k) responsible_rel_id: a person that is assigned to the given PR, referred to as the Assigned To, (l) updated_by_rel_id: a specific ID of a person that the given PR
20 was last updated by, (m) date_current_state: a date/time that the status of the given PR was last changed, (n) date_closed: a date/time that the given PR was closed, if at all, (o) date_last_activity: a date/time that a PR Activity was last performed for the given PR, (p) customer_rel_id: a specific ID of a contact associated with the given PR, (q) entity_id: a specific ID of a company associated
25 with the given PR, and (r) date_updated: a date and time that a given record in the PR table was last updated.

Fields defined for a particular application

30 The following additional PR data fields are examples of additional fields that can be defined as needed): (s) category_type: a value from a "Category" pick-list, with possible selections such as: "Hardware", "Software", and "Documentation", (t) reason_opened_type: a value from a "Reason Opened" pick-list, with possible selections such as: "Service Request", "Problem Report", and "Request for Information", (u) priority_type: a value from a "Priority" pick-
35 list, with possible selections such as: "Low", "Medium", and "High", (v) severity_type: a value from a "Severity" pick-list, with possible selections such as: "Low", "Medium", and "High", (w) exposure_type: a value from an "Exposure" pick-list, with possible selections such as: "Limited", "All Customers", and "All Customers and Employees", (x) required_time: estimated
40 time to complete the given PR, (y) required_cost: estimated time to complete the given PR.

Project table 831

A record in Project table 831 looks like this:

```

5  Project (
      id                NUMBER(12) NOT NULL,
      name              VARCHAR2(80) NOT NULL,
      division_id       NUMBER(6) NOT NULL,
      project_type       NUMBER(6) NOT NULL,
      created_by_rel_id  NUMBER(12) NOT NULL,
10  updated_by_rel_id   NUMBER(12) NOT NULL,
      date_created      DATE NOT NULL,
      date_updated      DATE NOT NULL,
      primary key(id)
15  )

```

TOTAL "TABLES"

Project table 831 has a record for all of the projects defined for a given database. As described above, every PR record is associated with a given Project, and thus, it can be said that all PRs in a database are "grouped" by their respective Projects. Similarly, a Project is associated with a given record in Division table 829, and thus, it can be said that all Projects in a database are further "grouped" by their respective Divisions.

This table contains the following data fields: (a) id: a unique ID in this table, (b) name: Project name, e.g., "Customer Support", "R&D Work Items", and "Assembly Line Controls", (c) division_id: a specific Division ID that a given Project is associated with; thus enabling the grouping of Projects by Divisions, (d) project_type: a value from a "Project Type" pick-list, with possible selections such as: "Manufacturing", "Administrative", and "Human Resources", (e) created_by_rel_id: a specific ID of a person who created the given Project record in this table, (f) updated_by_rel_id: a specific ID of a person that last updated the given Project record in this table, (g) date_created: date/time that the given Project record was created in this table, (h) date_updated: the date and time that this record was last updated.

Division table 829

A division table record looks like this:

```

Division (
    id                NUMBER(12) NOT NULL,
    name              VARCHAR2(80) NOT NULL,
    created_by_rel_id NUMBER(12) NOT NULL,
    updated_by_rel_id NUMBER(12) NOT NULL,
    date_created       DATE NOT NULL,
    date_updated       DATE NOT NULL,
    primary key(id)
)

```

The **Division** table is a table that contains all Divisions defined for a given database. A Division is a group of Projects, and a Project is a group of PRs.

This table contains the following data fields: (a) id: a unique ID in this table, (b) name: Division name, e.g., "California Site", and "New Jersey Site", (c) created_by_rel_id: a specific ID of a person who created the given Project record in this table, (d) updated_by_rel_id: a specific ID of a person that last updated the given Project record in this table, (e) date_created: date/time that the given Project record was created in this table, (f) date_updated: the date and time that this record was last updated.

PR activity tables 835

PR_activity type table 837 contains the PR activity types for the activities performed manually by users of system 801 or automatically by system 801 itself when an administrative query returns a non-empty result set. PR_activity table 839 is the collection of all activities, of either class, that were performed or are scheduled to be performed for all the processes represented by PR records in PR table 833.

PR_activity_type table 837

A record in PR_activity_type table 837 looks like this:

```

10  PR_activity_type (
      id          NUMBER(12) NOT NULL,
      is_admin    NUMBER(1) NOT NULL,
      name        VARCHAR2(80),
      can_schedule NUMBER(1),
15  min_members   NUMBER(2) NOT NULL,
      require_summary NUMBER(1) NOT NULL,
      summary_prompt VARCHAR2(120),
      can_edit     NUMBER(1) NOT NULL,
      edit_summary_only NUMBER(1) NOT NULL,
20  date_updated  DATE NOT NULL,
      primary key(id)
  )

```

Each record in **PR_activity_type table 837** represents a PR activity type. If the value of the is_admin field is 1, the record belongs to Admin_activity_type subtable 841 and represents an Admin activity type. The PR_activity table contains the following data fields: (a) id: a unique ID in this table, (which unique ID is referred to as pr_activity_type 609 by related tables seen in FIGs. 6 and 7), (b) is_admin, described above; (c) name: a specific name given to the PR Activity Type, e.g., "Call Customer", "Work Initiated", and "Close - Done", (d) can_schedule: if the value equals one, such a PR Activity Type can be scheduled by a user, otherwise, it can only be posted as a performed activity, (e) min_members: minimum number of activity participants that are required for the given PR Activity Type, (f) require_summary: if the value equals one, the given PR Activity Type can be performed only if an activity summary is entered, (g) can_edit: if the value equals one, a PR Activity performed using the given PR Activity Type can be edited, otherwise, it can not be edited at all, (h) edit_summary_only: if the value equals one, the summary of the PR Activity performed using the given PR Activity Type can be edited, otherwise, it can not be edited at all, and (i) date_updated: the date and time that this record was last updated.

When a record represents an Admin_activity_type, some of the fields have special values: can_schedule is not relevant, it is actually set to zero (0).

Similarly, min_members = 0, and require_summary and summary_prompt are set to "neutral", meaningless values. The field can_edit is set to 0, as is edit_summary_only.

5 *PR_activity table 839*

A record in PR_activity table 839 looks like this:

```

PR_activity (
  id                NUMBER(12) NOT NULL,
  pr_id             NUMBER(12) NOT NULL,
10  pr_activity_type NUMBER(6),
  short_description VARCHAR2(120),
  summary           LONG,
  date_posted       DATE NOT NULL,
  date_scheduled    DATE,
15  date_performed   DATE,
  posted_by_rel_id  NUMBER(12) NOT NULL,
  updated_by_rel_id NUMBER(12) NOT NULL,
  responsible_rel_id NUMBER(12),
  status_origin     NUMBER(6),
20  status_after     NUMBER(6),
  date_updated      DATE NOT NULL,
  primary key(id)
)
```

25 **PR_activity** table 839 is a table that contains records representing activities that are scheduled to be or have been performed for processes represented by PR records. Each record indicates the activity's PR_activity type and the PR record for the process. When a record is added to PR_activity table 839 as a result of the scheduling or performance of an activity for a process, the activity is said to have been *posted*. A PR activity record contains the following data fields: (a) id: a unique ID in this table. (b) pr_id: the ID of the record in PR table 833 with which this record is associated; (c) pr_activity_type: the identifier of a record in PR_activity_type table 837 that represents the activity's PR_activity type, (d) short_description: a short summary of the activity, e.g., "Called customer to clarify request", (e) summary: detailed description of the actions taken by the activity, (f) date_posted: date/time that the given record in the PR_activity table was created, (g) date_scheduled: date/time that the given PR Activity is scheduled to be performed, (h) date_performed: date/time that the given PR Activity was performed; this value is null if not yet performed, i.e., if still scheduled, (i) posted_by_rel_id: a specific ID of a person who posted the given PR Activity, (j) updated_by_rel_id: a specific ID of a person who last updated the given PR Activity, (k) responsible_rel_id: a specific ID of a person that is responsible for performing the given PR Activity, (l) status_origin: a PR status that was in effect prior to performing the given PR Activity, e.g., "Opened", (m)

status_after: a PR status that went into effect after performing the given PR Activity, e.g., "Work in Progress", and (n) date_updated: the date and time that this record was last updated.

When the activity represented by a record in PR_activity table 837 is an administrative activity, posting occurs only after system 801 has performed the administrative activity. System 801 automatically sets many of the above data fields to special values when it posts the record. The date scheduled is set to null, the date_performed is the then date/time that system 801 has posted the record, and the responsible_rel_id is set with a symbolic "admin" user, as is the posted_by_rel_id. Summary is set with an indication that "this activity is an administrative activity posted due to certain conditions with regard to the PR. Also included in the summary is the PR_query.description, i.e., the value in the 'description' field of the PR_query record for the administrative query whose execution caused the administrative action to be performed.

Administrative query tables 845

Admin_query table 853 contains a record for each of the administrative queries, referred to as Admin Query (AQ), which system 801 can make. An administrative query has the following components:

- a query (the query is an SQL query in a preferred embodiment);
- a scope specifier for the query. The scope specifier specifies a subset of the records in PR 833 over which the query will be run;
- a schedule specifier for the query; this contains information that system 801 uses to figure out when the query is to be executed;
- an initial administrative activity specifier, which specifies an administrative activity which will be performed when a PR record which is returned by an execution of the administrative query is in the state of First Occurrence with regard to the execution of the administrative query.

An administrative query is further associated with a program sequence that specifies administrative activities that are performed for returns of the specific record in PR 833 by executions of the administrative query for which the record is in the state of Persistent Conditions with regard to the execution. The states of Persistent Conditions and First Occurrence will be described in more detail in connection with the discussion of log tables 871.

As shown in FIG. 6, the definition of each of the administrative query's components is contained in a record in another table that is referenced by the record in the Admin_query table 853; thus, the query is defined by a record in PR_query table 847, the scope by a record in AQ_scope table 849, the schedule by AQ_schedule table 851, and the initial administrative activity by the record in

PR_activity_type table 837 for the initial administrative activity's Administrative activity type. One consequence of this arrangement is that queries, scopes, schedules, and Administrative activity types may be shared by any number of administrative queries, which greatly simplifies the configuration of administrative queries in system 801. Types of administrative activities which are performed when a PR record which is returned by an execution of an administrative query is in the state of Persistent Conditions with regard to that execution are specified in Program_sequence table 855. All of these tables will be described in detail in the following.

Admin_query table 853

A record in Admin_query table 853 looks like this:

```
Admin_query (
    id                NUMBER(12) NOT NULL,
    pr_query_id       NUMBER(12) NOT NULL,
    aq_scope_id       NUMBER(12),
    aq_schedule_id    NUMBER(12) NOT NULL,
    pr_activity_type  NUMBER(12) NOT NULL,
    aq_priority_type  NUMBER(6) NOT NULL,
    is_active         NUMBER(4) NOT NULL,
    date_updated      DATE NOT NULL,
    primary key(id)
)
```

The **Admin_query** table specifies all the components of the Admin Query (AQ). This table contains the following data fields: (a) id: unique Admin Query ID, referred to as the AQ ID, (b) pr_query_id: the ID of the record for the query to be executed in PR_query 847, (c) aq_scope_id: the ID of record for the scope to be used in AQ_scope 849, (d) aq_schedule_id: the ID of the record for the schedule to be used in AQ_schedule 851, (e) pr_activity_type: the unique identifier for the initial activity's Admin activity type record in PR_activity_type table 837; (f) aq_priority_type: the Priority Group that this AQ should be executed under; the priority of the administrative query represented by this record is indicated by a value between 1 and 10 in this field; in single server systems, the priority decides the order in which a set of administrative queries that are scheduled to be executed at the same time are in fact executed; in multiple-server systems, the priority is also used to determine which servers execute which administrative queries; (g) is_active: indicates whether the given AQ is still active, i.e., should this AQ be considered for execution as scheduled, or is it a "retired" AQ, i.e. one that should no longer be executed, and (h) date_updated: the date and time that this record was last updated. It should also be noted that in other embodiments, the initial administrative activity might

simply be the administrative activity specified in the first record in the query's program sequence.

PR_query table 847

5 A record in PR_query table 847 looks like this:

```

PR_query (
    id          NUMBER(12) NOT NULL,
    name        VARCHAR2(40) NOT NULL,
    sql_from    VARCHAR2(256) NOT NULL,
10    sql_where  LONG NOT NULL,
    description VARCHAR2(1024),
    date_updated DATE NOT NULL,
    primary key(id)
)

```

15

Administrative queries are SQL queries. **PR_query** table 847 specifies the SQL FROM, WHERE, and ORDER clauses of the SQL query. This table contains the following fields of data: (a) id: unique Query ID, (b) name: given Query name, (c) sql_from: the SQL FROM clause, (d) sql_where: the SQL WHERE clause, (e) description: the description (user language) of what the Query is about, and (f) date_updated: the date and time that this record was last updated.

20

AQ_scope table 849

A record in this table looks like this:

```

25  AQ_scope (
    id          NUMBER(12) NOT NULL,
    name        VARCHAR2(254) NOT NULL,
    projects_ids TEXT NOT NULL,
    date_updated DATE NOT NULL,
30    primary key(id)
)

```

30

A record in **AQ_scope** table 849 specifies a scope for an administrative query, that is, it defines a subset of the records in PR 833 over which the query is to run. In the preferred embodiment, the subset is defined by specifying selected projects defined in Project table 831. The subset is made up of all of the records in PR table 883 whose project_id fields specify records in Project table 831 for the selected projects.

This table contains the following data fields: (a) id: unique Scope ID, (b) name: given Scope name, (c) project_ids: a list of the names of all projects to be included (thus, filtering out other projects); the names are values of name fields in records in Project table 831; and (d) date_updated: the date and time that this record was last updated.

AQ_schedule table 851 and AQ_schedule_detail table 852

These tables contain information that system 801 uses to schedule the next execution of an administrative query. Beginning with AQ_schedule table 851, a record in the table has the following fields:

```
AQ_schedule (
    id                NUMBER(12) NOT NULL,
    name              VARCHAR2(254) NOT NULL,
    date_updated      DATE NOT NULL,
    primary key(id)
)
```

A record in AQ_schedule table 851 specifies a schedule for executing an administrative query. This table contains the following data fields: (a) id: unique Schedule ID, (b) name: given Schedule name, and (d) date_updated: the date and time that this record was last updated. The value of the unique identifier for the record is used to locate a record in the AQ_schedule_detail table that contains the actual information used to schedule the query.

A record in AQ_schedule_detail table 852 looks like this:

```
AQ_schedule_detail (
    id                NUMBER(12) NOT NULL,
    aq_schedule_id    NUMBER(12) NOT NULL,
    day_in_week        NUMBER(4),
    day_in_month       NUMBER(4),
    start_time         NUMBER(6),
    end_time           NUMBER(6),
    time_interval      NUMBER(12,2),
    date_updated       DATE NOT NULL,
    primary key(id)
)
```


A record in AQ_schedule_detail table 852 specifies the Schedule details for the AQ schedule represented by the record in AQ_schedule table 851 referred to by the value in the aq_schedule_id field. The schedule detail determines when an administrative query that specifies the schedule will be executed. This table contains the following data fields: (a) id: unique ID in this table, (b) aq_schedule_id: the ID of the record in AQ_schedule table 851 for the schedule that is using this Schedule Detail, (c) day_in_week: day in the week that the query is to be executed, e.g., 1 = Sunday, 2 = Monday, etc. (d) day_in_month: day in the month to be executed, e.g., 1 = the first day in the month, 2 = the second day in the month, etc., (e) start_time: the first time to execute the AQ during the given day, (f) end_time: the last time to execute the Query in the given day, (g) the time interval, specified in minutes, between consecutive Query executions, and (h) date_updated: the date and time that this record was last updated.

When an administrative query that uses the AQ_schedule detail record is executed, the information in the AQ_schedule_detail record is used to update the administrative query's record in current schedule table 823 to specify the next execution of the query. Where a time interval is specified, it is added to the time specified for the last execution of the query in the administrative query's record in current schedule table 823. The administrative query thus effectively schedules its next execution itself. One advantage of this arrangement is that the form of a record in current schedule table 823 is independent of the kind of scheduling being done; further, the table itself need have only one record for a given administrative query, regardless of the frequency with which the given administrative query is being executed or the complexity of its execution schedule.

Program_sequence table 855

Program_sequence table 855 specifies additional activities that can be performed for a process whose record in PR 833 has been retrieved by an execution of an administrative query with regard to which the retrieved PR record is in the state of Persistent Conditions. A record in Program_sequence table 855 looks like this:

Program_sequence (

```

    id                NUMBER(12) NOT NULL,
    admin_query_id     NUMBER(12) NOT NULL,
    sequence_number    NUMBER(6) NOT NULL,
    time_interval      NUMBER(12,2),
    pr_activity_type   NUMBER(12),
    program_control    NUMBER(6) NOT NULL,
    date_updated       DATE NOT NULL,
    primary key(id)

```

)

There may be a number of records in Program_sequence table 855 for a given administrative query. The set of records for the given administrative query is called the administrative query's program sequence. The program sequence associated with a given administrative query specifies administrative activities that are to be executed with regard to a PR record that is in a state of Persistent Conditions with regard to the current execution of the administrative query. The set of records specifies not only the administrative activities, but also the order in which they are performed by executions of the administrative query for which the PR record is in the state of Persistent Conditions, and the temporal conditions under which they are to be executed. The parts of a program sequence record that specify these things are termed *instruction elements*, and taken together, the instruction elements in a program sequence record define an *instruction*. In the preferred embodiment, each record in Program_sequence table 855 specifies a set of three instruction elements: a Type instruction element, an Admin Activity Type instruction element, and an Elapsed Time instruction element. The Type instruction element specifies the Program sequence record that will be used the next time the query with which the program sequence record is associated is executed; the Admin Activity Type instruction element specifies the Administrative activity type of the activity to be performed and is thus a pr_activity_type field 609 referencing Admin_activity_type subtable 841; the Elapsed Time instruction element specifies a minimum time from the time the last administrative activity was executed by the query for a given PR record to the time the administrative activity specified by this Program_sequence record is to be executed. Other embodiments may have different instruction elements and more or fewer of them.

A record in Program_sequence table 855 contains the following data fields: (a) id: unique Program Sequence record ID, (b) admin_query_id: the id of the record in Admin_query 853 for the query that this record is associated with, (c) sequence_number: the sequence number for the record in the program sequence for the administrative query specified by the value of admin_query_id; (d) time_interval: the Elapsed Time instruction element, (e) pr_activity_type: the Admin activity type of the activity to be performed; this field is the Admin Activity Type instruction element; (f) program_control: the Type Instruction Element; this field may have values from the group of: (f1) Stop, (f2) Next, or (f3) Continue, where Stop means ceasing to execute any further administrative activities for a given PR record while the given PR record is in the state of Persistent Conditions with regard to an execution of the Admin Query, Next means using the next program sequence record in the query's program sequence the next time the query is executed, returns the given PR record, and the given PR record is in the state of Persistent Conditions with regard to the execution, and Continue means again executing the present program sequence record the

next time the query is executed returns the given PR record, and the given PR record is in the state of Persistent Conditions with regard to the execution, and (g) date_updated: the date and time that this record was last updated. It should be noted that in other embodiments, the Type instruction element may be able to specify any program sequence record in the query's program sequence, i.e., the Type instruction element may function as a "goto" or include a conditional branch.

The Elapsed Time Instruction element specifies the minimum elapsed time from the previous time that an administrative activity was performed for a given administrative query and a given PR record to the time when the administrative activity specified in the current record in the Program_sequence table 855 should next be executed. More specifically, if a PR record is in the state of Persistent Conditions when the given administrative query is executed again, but the time elapsed from the last action taken to the current time is less than the specified Elapsed Time, then the administrative activity specified in the current program sequence record will not be performed and the current value of the Next Sequence Pointer will remain unchanged. As a result, the same record in the Program Sequence Table will be considered again if the state of Persistent Conditions still exists for the given PR record on the next execution of the given AQ that returns the given PR record.

Example of a program sequence and its execution

An example of a program sequence associated with an administrative query "All Past Due Items" that returns PR records 833 with items that have passed their deadlines without action being taken is the following:

Program sequence record for the "All Past Due Items" query with sequence_number = 1:

Type = "Next";

Elapsed Time = 30 minutes; and

Administrative activity type to be Executed = "Send email notification and escalate priority"

Program sequence record for the "All Past Due Items" query with sequence_number = 2:

Type = "Continue";

Elapsed Time = 24 hours; and

Administrative activity type to be Executed = "Notify management"

According to this example, if the AQ "All Past Due Items" is scheduled for execution every day and once every hour of the day, and if PR record #1012 was first included in the Result Set (the set of records returned by the query) at 10:00

AM on a given day, then the Initial administrative activity specified in the query will be executed with regard to PR record #1012 and a Next Sequence Pointer in the record for the query and PR record in AQ_PR_log 875 will be set to the numeric value of one. Thereafter, if this PR is in the state of Persistent

5 Conditions (as determined from records for the query and PR record in Admin_query_log 873 and AQ_PR_log 875) at 11:00 AM, system 801 will retrieve the record in the query's program sequence in which sequence_number=1, and since the specified Elapsed Time is 30 minutes and the actual elapsed time from the previous execution is one hour, the condition of the Elapsed Time will have

10 been satisfied and system 801 will execute the Administrative activity type specified by the value of the record's pr_activity_type and will increment the Next Sequence Pointer by one, so that it points to the second program sequence record in the program sequence.

When system 801 next executes the administrative query associated with

15 the program sequence at 12:00 PM, if PR #1012 is still part of the result set and PR #1012 is in the state of Persistent Conditions, system 801 will follow Next Sequence Pointer to the second record in the program sequence for the administrative query. However, since the Elapsed Time specified for this sequence record is 24 hours, and since the actual elapsed time from the previous

20 execution is only one hour, the condition of Elapsed Time of 24 hours will not be satisfied and therefore the administrative activity for this sequence record will not be performed. Since the administrative activity was not performed, the Next Sequence Pointer will not be incremented. The specified administrative action will only be performed if PR #1012 continues to be in the state of Persistent

25 Conditions throughout the next 23 hours, and it will not be until system 801 executes the "All Past Due Items" AQ the next day at 11:00 AM that the "Elapsed Time" Instruction Element of 24 hours will be satisfied, at which time system 801 will perform the administrative action of the type "Notify Management" specified for the second record in the program sequence. Having performed the

30 administrative action, system 801 will perform the operation specified by Type on the Next Sequence Pointer. Type specifies "Continue", and consequently, system 801 will not change the value of the Next Sequence Pointer. Therefore, as long as PR #1012 stays "Past Due", management will continue to be notified every day at 11:00 AM that PR #1012 is in such a state. The above example

35 shows how detection of the state of Persistent Conditions and an administrative query's program sequence can be used to enable system 801 to check the status of a process with a high degree of frequency without generating notifications on every status check.

It should be pointed out here that, seen in general terms, an

40 administrative query's program sequence defines a set of behaviors that correspond to a set of substates that a PR record may be in when the PR record is in the state of Persistent Conditions with regard to an execution of an

administrative query. In the preferred embodiment, information about what substate a given PR record is presently in is preserved between executions of the query in the Next Sequence Pointer in the record for the query and the given PR record in AQ_PR_log 875. In other embodiments, the substate information may be preserved between executions of the query in other forms.

Details of log tables 871

Admin_query_log table 873 and AQ_PR_log 875 together contain the information that system 801 uses to determine when to perform the next administrative activity for a PR record returned by an execution of a given administrative query and what administrative activity the next administrative activity should be.

Admin_query_log 873

A record in this table looks like this:

Admin_query_log (

	id	NUMBER(12) NOT NULL,
	aq_scope_id	NUMBER(12),
	admin_query_id	NUMBER(12) NOT NULL,
	pr_query_id	NUMBER(12) NOT NULL,
	host_name	VARCHAR2(254),
	datetime_executed	DATE NOT NULL,
	pr_count_matched	NUMBER(12),
	pr_count_executed	NUMBER(12),
	date_updated	DATE NOT NULL
)	

Admin_query_log table 873 logs the execution of every administrative query by system 801. There is a record for every execution of each of the administrative queries. Records in the table contain the following data fields: (a) id: unique AQ Log ID, (b) aq_scope_id: the ID of the record in AQ_scope table 849 for the scope of the execution of the administrative query represented by the record; (c) admin_query_id: the ID of the record in Admin_query table 853 for the administrative query whose execution is represented by the Admin_query_log record; (d) pr_query_id: the ID of the record in PR_query 847 that defines the query used in the execution represented by the record; (e) host_name: which server this AQ executed on in the execution represented by the record, (f) datetime_executed: the date and time of the execution represented by the record; this field is set after system 801 has performed any necessary administrative actions on all of the PR records in the result set returned by the administrative query; this value is further one of the values used to determine whether Persistent Conditions exist with regard to the current execution of the

- administrative query and a particular PR record returned by the execution; (g) pr_count_matched: the count of PRs that matched given Query (set of conditions) in the execution represented by the record; (h) pr_count_executed: the count of PRs for which an administrative action was performed during the execution represented by the record, and (i) date_updated: the date and time that this record was last updated.

AQ_PR_log table 875

- 10 This table has a record corresponding to each PR record returned by a given execution of an administrative query. This record further contains the Next Sequence Pointer that determines which Administrative activity type will next be executed by system 801 for the given query and PR record.

AQ_PR_log (

- 15 id NUMBER(12) NOT NULL,
 admin_query_id NUMBER(12) NOT NULL,
 pr_id NUMBER(12) NOT NULL,
 date_aq_executed DATE,
 date_aa_executed DATE,
 pr_activity_type NUMBER(12) NOT NULL,
 next_sequence NUMBER(6),
 date_updated DATE NOT NULL
)
)

- 25 **AQ_PR_log** table 875 logs PR records that were returned when a given administrative query was executed. Each record represents a particular PR record-administrative query execution pair. A record contains the following data fields: (a) id: unique id of the record in the table, (b) admin_query_id: the ID of the particular administrative query that was executed, (c) pr_id: an identifier for the PR record that was returned when the given administrative query was executed; (d) date_aq_executed: the date and time of the particular execution of the administrative query; this value is equal to the value of the datetime_executed field in the Admin_query_log table record for the same particular execution of the administrative query; (e) date_aa_executed: the date and time that the last administrative action was performed for the administrative query and PR record; (f) pr_activity_type: the Administrative activity type for the most recently performed administrative activity; (g) next_sequence: the value of the Next Sequence Pointer, and (h) date_updated: the date and time that this record was last updated.
- 40 Using AQ_PR_log table 875 and Admin_query_log 873 to determine whether a process represented by a PR record is in a state of Persistent Conditions or a state of First Occurrence

A given PR record is in a *state of Persistent Conditions* with regard to an execution of a given administrative query that returns the given PR record if the immediately preceding execution of the given administrative query also returned the given PR record. This of course means that the process condition which the given administrative query is intended to monitor is persisting with regard to the given PR record. If the given PR record is not in a state of Persistent Conditions, it is in a *state of First Occurrence*.

When system 801 executes the given administrative query, the execution returns the given PR record, and the given PR record is in a state of First Occurrence with regard to the execution, system 801 performs the initial administrative action specified for the given administrative query. When the given PR record is in a state of Persistent Conditions with regard to the execution, system 801 performs the administrative action specified in the Program_sequence table record for the given administrative query that is pointed to by the current value of the Next Sequence Pointer.

A preferred embodiment of system 801 detects the existence of a state of Persistent Conditions or a state of First Occurrence for a given execution of an administrative query and a given PR record returned by that execution from the information about executions of the given administrative query that is contained in Admin_query_log table 873 and the information about executions of the given administrative query and the PR records they returned that is contained in AQ_PR_log table 875. The state of Persistent Conditions is detected as follows: when system 801 is executing a given administrative query and the administrative query returns a result set that includes a given PR record, system 801 searches in AQ_PR log record for a record that matches the given PR record and given administrative query. If such a record is found, system 801 compares the value of the date_aq_executed field in the AQ_PR log record with the value of the datetime_executed field of the most recent Admin_query_log record for the given administrative query. There are three possible outcomes:

1. There may be no AQ_PR_log record at all for the given PR record and the given administrative query; if that is the case, this is the first time the given PR record has been part of the result set returned by the given administrative query and the given PR record is in a state of First Occurrence for this execution of the given administrative query.
2. There is an AQ_PR_log record for the given PR record and the given administrative query, but the value in the date_aq_executed field is less recent than the value in the datetime_executed field in the most recent Admin_query_log record for the given query, indicating that the immediately preceding execution of the given query did not return the given PR record in its result set and that the given PR record is therefore not in the state of Persistent Conditions; thus the

given PR record will again be in the state of First Occurrence for this execution of the given administrative query.

3. There is an AQ_PR_log record for the given PR record and the given administrative query, and the value in the date_aq_executed field is equal to the value in the datetime_executed field in the most recent Admin_query_log record for the given query, indicating that the immediately preceding execution of the given query did return the given PR record in its result set; thus the given PR record is in the state of Persistent Conditions for this execution of the given administrative query.

A scenario that will produce outcome (2) above is the following: an administrative query called "Find overdue PR records" returns all PR records where the value of the is_closed field is zero, indicating that the record is still open, and the value in the date_due field is less recent than the time of the current execution of the administrative query. The administrative query is run every hour. PR record #120, has a date_due field that specifies 11:30. When the administrative query is run at 12:00, it returns PR record #120. Then, at 12:30, the person responsible for the process extends the deadline by setting the date_due field in record #120 to 1:30. When the administrative query is run at 1:00, it does not return PR record #120. The 1:30 deadline is also not met, and when the administrative query is run at 2:00, it again returns PR record #120; however, since the administrative query returned PR record #120 at 2:00 but did not return it at 1:00, PR record #120 is not in the state of Persistent Conditions with regard to the "Find overdue PR records" administrative query at 2:00, but is instead again in the state of First Occurrence.

AQ_trends table 879

As shown in Fig. 8, this table properly belongs to administrative queries tables 845. AQ_trends table 879 logs information which system 801 can use to determine trends in the way in which the processes being monitored by a given administrative query are behaving and to perform administrative actions as determined by those trends.

There may be a record in this table for every administrative query for which trends are being tracked. The record for a given administrative query can be configured to recognize trends over a particular time interval in the number of PR records returned by executions of the given administration query and to specify administrative activities for particular trends. When a particular threshold is reached and detected during an execution of the administrative query, the execution of the administrative query may result in the performance of an administrative action on a particular PR record that is separate from the PR

records returned by the administrative query. The interaction between the record for an administrative query in the AQ_trends table and executions of the administrative query is another example of conditional performance of an administrative action based on a condition that is detected during execution of the query.

One administrative activity specified in the AQ_trends table record may set a field in the separate PR record indicating that the threshold for a trend in one direction has been exceeded, and another may reset that field if a trend is below the given threshold. The determination of "exceeding" the threshold or going "below" a given threshold is dependent on a direction qualifier. Another administrative query may query PR records set by these administrative activities and when one of these records is in a state of Persistent Conditions over time, indicating that a trend is continuing, an execution of the other administrative query may result in performance of an administrative activity that notifies someone or takes some other action to remedy the trend.

A record in AQ_trends table 879 has the form:

```

AQ_trends (
  id                NUMBER(12) NOT NULL,
  admin_query_id    NUMBER(12) NOT NULL,
  time_interval     NUMBER(12,2) NOT NULL,
  direction_type    NUMBER(2) NOT NULL,
  percentage_set     NUMBER(12,4),
  percentage_reset  NUMBER(12,4),
  pr_id             NUMBER(12) NOT NULL,
  aa_post_on_set    NUMBER(12),
  aa_post_on_reset  NUMBER(12),
  date_updated      DATE NOT NULL
)

```

A record in AQ_trends table 879 can be configured to respond to trends visible in the executions of the administrative query associated with the record, based on the number of PR records that match given administrative query, as reflected in the values of the 'pr_count_matched' field in the query's Admin_query_log table 873, and the behavior of the values of that field over time. This table contains the following data fields: (a) id: unique ID in this table, (b) admin_query_id: the ID of the specific administrative query, which the given record is configured for, (c) time_interval: a specific time interval, across which a trend is calculated, e.g., 24 hours, (d) direction_type: an indicator for whether a watch is on an increase in 'pr_count_matched', or a decrease in same, (e) percentage_set: is a threshold, which when exceeded, will cause system 801 to perform a "set" administrative activity during execution of the administrative query on a PR record; (f) percentage_reset: is a threshold, below which the same is done with a "reset" administrative activity; (g) pr_id: a unique identifier for the

- PR record which will be operated on by the set and reset administrative activities, (h) aa_post_on_set: an identifier for the record in Admin_activity_type table 841 for the set administrative activity's administrative activity type; (i) aa_post_on_reset: the same for the reset administrative activity, and (j)
- 5 date_updated: the date and time that this record was last updated.

Details of action tables 857

The actions performed by system 801 when it executes a given Administrative activity type are described in records in action tables 857 whose pr_activity_type fields contain the unique identifier of the given Administrative activity type's record in PR_activity type table 837. There are a number of kinds of actions, and each kind has its own table in action tables 857. If an Administrative activity type is seen as a kind of program, the actions associated with a given Administrative activity type can be seen as the Administrative activity type's instructions. As with normal program instructions, the action performed by a given program instruction may depend on a value that is obtained at runtime. When the actions belonging to a given administrative activity are executed, they are executed in the order given by the values of the action records' identifiers. In other embodiments, there may be other provisions for establishing an order in which the actions are executed and there also may be provisions for gotos and conditional branches. An important aspect of the present invention is the ability to easily modify pre-existing Administrative activity types. To modify an administrative activity type, one needs only modify the records in action tables 857 for the actions belonging to the administrative activity type, either by adding or deleting records or editing existing records. Modification of an administrative activity is not only easy, but safe, since the modifications are constrained by the fields available in the action records being added, deleted, or edited.

In a preferred embodiment, there are three broad classes of actions: those which modify a PR record which belongs to the result set returned by an administrative query; those which post records for activities to the PR_activity table, and one action which generates a report about the PR records in the result set returned by the administrative query. The relationship between these classes of actions and the kinds of actions are as follows:

- Kinds of actions which modify PR records:
 - 35 - AA_set_values actions in table 859: these actions set or increment fields in PR records that contain neither person nor date values.
 - AA_set_person actions in table 863: these actions set fields in PR records that contain person values. A person value is an identifier for a person known to system 801.
 - 40 - AA_set_dates actions in table 861: these actions set fields in PR records that contain date values. The date fields are set with

reference to other date fields in the PR records or with reference to the date and time when an administrative activity is performed.

- Kinds of actions which post records in PR_activity table 839:
 - AA_post_activities actions in table 865: these actions post records for any kind of activity type in PR_activity table 839. The posting may either schedule an activity for performance or indicate that the activity has been performed.
 - PR_notification actions in table 865: these actions generate and send a notification to a list of people that is associated with the process's PR record, post a record to PR_activity table 839 for the notification, and makes a record in another table (not shown) which indicates who received notifications.
- Report generating actions:
 - AA_exec_report actions in table 865: generates a report which includes all the PR records of the result set returned by the administrative query that is performing the administrative activity that contains the action, formats the report based on a specified report template, converts its to a PDF file, and mails out the PDF file as an attachment to recipients based on a configurable recipient list.

An action table record associated with a given Administrative type may come from any of the action tables and an Administrative type may have any number of action table records associated with it. To clarify by example, for a given Administrative activity type, system 801 can be configured to have no records in AA_set_values actions table 859, which means that upon performing this given Administrative activity type, there will be no effect on any non-date or any non-person field values in the matching PR records; one record in the AA_set_person actions table 863, indicating one specific person field to be affected; and three records in AA_set_dates actions table 861, indicating three specific date or date-time fields to be affected by this given Administrative activity type. The same is true for the other kinds of actions.

It should be pointed out here that in general, the kinds of actions defined for an embodiment of the invention will depend on the kind of process being controlled by the invention. The kinds of actions in the preferred embodiment are typical for embodiments that are intended to control business and administrative processes. Embodiments that are intended to control industrial or technical processes may have actions that result in physical actions being performed. Examples might be sounding an alarm, adjusting a valve, or rerouting a stream of packets. The details of the action tables are presented in the order of the above taxonomy.

AA_set_values table 859

The actions represented by the records in this table affect values in PR records returned by the administrative query that performs an administrative activity which includes the record's action.

Records in this table have the following form:

```

AA_set_values (
  id                NUMBER(12) NOT NULL,
  pr_activity_type  NUMBER(12) NOT NULL,
  data_field_id     NUMBER(12) NOT NULL,
  action_type       NUMBER(6)  NOT NULL,
  set_type_id       NUMBER(12) NOT NULL,
  date_updated      DATE NOT NULL
)

```

Records in **AA_set_values** table 859 contain the following data fields: (a) id: unique ID of the record in this table, (b) pr_activity_type: the ID of a record in table 837 for a specific administrative activity type to which the action belongs; (c) data_field_id: a value that specifies what field is to be affected by the action in the PR records of the result set returned by the query execution that is performing the administrative activity. There is a value of data_field_id associated with each of the fields that is defined for a PR record, (d) action_type: action to be taken: incrementing the current value of the field specified by the value of data_field_id, or setting that field to a pre-determined value, (e) set_type_id: a value to be used in setting the specified field; when action_type specifies increment, the value of set_type_id is the value by which the value in the field specified by data_field_id is to be incremented (or decremented); otherwise, it is a constant value to which the field is to be set, and (f) date_updated: the date and time that this record was last updated.

AA_set_person table 863

The actions represented by the records in this table affect person values in PR records returned by the administrative query that performs an administrative activity which includes the record's action.

Records in this table have the following form:

```

AA_set_person (
  id                NUMBER(12) NOT NULL,
  pr_activity_type  NUMBER(12) NOT NULL,
  data_field_id     NUMBER(12) NOT NULL,
  person_role_type  NUMBER(12) NOT NULL,
  person_rel_id     NUMBER(12) NOT NULL,
  date_updated      DATE NOT NULL
)

```

Records in this table contain the following data fields: (a) id: unique ID of the record in this table, (b) pr_activity_type: the ID of the record in PR_activity_type table 837 of the Administrative activity type to which this action belongs; (c) data_field_id: an identifier for the field in the PR record that is to be affected by the action, (d) person_rel_id: if not null, the value to be assigned to the field specified by data_field_id; this value is an identifier for a specific person, (e) person_role_type: if not null, a value for a role that is to be assigned to the affected field; in this case, system 801 will select an ID of a person from a circular list of persons with the given role. System 801 remembers the last person selected from the list in conjunction with performance of an activity of the given Administrative activity type, so that on the next occurrence of such an activity, system 801 will select the next person on the given list; and (f) date_updated: the date and time that this record was last updated.

15 AA_set_dates table 861

The actions represented by the records in this table affect date or date and time values in PR records returned by the administrative query that performs an administrative activity which includes the record's action.

20 Records in this table have the following form:

```

AA_set_dates (
    id                NUMBER(12) NOT NULL,
    pr_activity_type  NUMBER(12) NOT NULL,
    data_field_id     NUMBER(12) NOT NULL,
    data_field_not_set NUMBER(12),
    not_set_add_value NUMBER(12),
    data_field_if_set NUMBER(12),
    set_add_value     NUMBER(12),
    business_days_rule NUMBER(2),
    date_updated      DATE NOT NULL
)
  
```

Records in this table contain the following data fields: (a) id: unique ID in this table, (b) pr_activity_type: the ID of the record in PR_activity_type table 837 that represents the administrative activity type that the action represented by the record belongs to; (c) data_field_id: an identifier for a date or date/time field in the PR record which is to be affected by the change, hereinafter the "affected field"; (d) data_field_not_set: an identifier for a field in the PR record whose value specifies a date or date/time type field; the field's value is used as a reference value when the current value of the affected field is null, (e) not_set_add_value: a numeric value to be added to the reference value of the when the affected field is null; the affected field is set to the result of the addition; (f) data_field_if_set: an identifier for a field in the PR record whose value specifies a date or date/time type field; the field's value is used as a reference value when the current value of the affected field is not null, (e) set_add_value: a numeric value to be added to the reference value when the affected field is non-null; the affected field is set to the result of the addition; (h) business_days_rule: a code specifying whether the value of the not_set_add_value or the set_add_value field represents business days or calendar days; and (i) date_updated: the date and time that this record was last updated. **Note 1:** 'not_set_add_value' and 'set_add_value' may be positive, negative, or zero and may also specify fractions of days. **Note 2:** if a reference field id equals a given constant, e.g., -1, this indicates to system 801 to not use any specific date or date/time field, but rather, the date/time of when the given administrative activity is executed, i.e., the then current time.

AA_post_activities table 865

Records in AA_post_activities table 865 represent actions that post records in PR_activity table 839 for non-administrative activities. The action may post the activity as either having been performed or scheduled to be performed.

Records in this table have the following form:

```
AA_post_activities (
  Id                NUMBER(12) NOT NULL,
  pr_activity_type  NUMBER(12) NOT NULL,
  post_activity_type NUMBER(12) NOT NULL,
  posting_mode      NUMBER(2) NOT NULL,
  data_field_date   NUMBER(12),
  add_value         NUMBER(12),
  business_days_rule NUMBER(2),
  data_field_person NUMBER(12),
  responsible_rel_id NUMBER(12),
  date_updated      DATE NOT NULL
)
```

Records in AA_post_activities contain the following data fields: (a) id: unique ID of the record in this table, (b) pr_activity_type: the ID of the record in PR_activity_type table 837 that represents the administrative activity type that the action represented by the record belongs to; (c) post_activity_type: the ID of the record in PR_activity_type table 837 that represents the activity type of the non-administrative activity being posted in PR_activity table 839; (d) posting_mode: a code specifying whether the non-administrative activity should be posted as a scheduled activity or as a performed activity, (e) data_field_date: an identifier for a field in the PR record whose value specifies a date or date/time type field; the field's value is used as a reference value to compute a date or date/time at which the non-administrative activity is to be scheduled for performance if the value of posting_mode indicates that the non-administrative activity should be scheduled, rather than performed right away; (f) add_value: a numeric value to be added to the reference value in the case where posting_mode indicates that the given activity should be posted as scheduled; the result of this addition will be used to set the date_scheduled field of the given PR Activity record; (g) business_days_rule: a code specifying whether the value of the add_value field represents business days or calendar days; (h) data_field_person: an identifier of a person type data field in the PR record the administrative activity is being performed on whose value is to be used to indicate the person responsible in the PR_activity record being posted; (i) responsible_rel_id: the value of this field is an identifier for a person who is the person responsible for the given PR Activity; the value will be used in the responsible_rel_id field of the PR_activity record being posted; (j) date_updated: the date and time that this record was last updated. **Note 1:** the value of 'add_value' is specified using any desired day or fraction of a day units. **Note 2:** the specifiers 'data_field_person' and 'responsible_rel_id' are mutually exclusive. **Note 3:** When posting a PR_activity record as a performed activity, system 801 sets the date_performed field of the PR_activity record to the date/time that said activity was posted by the system, yet leaves the date_scheduled field null, whereas when posting an activity as a scheduled activity, system 801 sets the date_scheduled field of the activity as explained above, yet leaves the date_performed field null.

PR_notification table 867

The actions represented in the records of this table generate a record in PR_activity_type table 837 for a notification activity that sends a notification to a list of people that are associated with the process's PR record, posts a record to PR_activity table 839 for the notification activity, and makes a record in another table that keeps track of who received notifications.

Records in table 867 have the following form:

PR_notification (

5 id NUMBER(12) NOT NULL,
 project_id NUMBER(12) NOT NULL,
 pr_activity_type NUMBER(6) NOT NULL,
 trigger_type NUMBER(6) NOT NULL,
 pr_owner NUMBER(1) NOT NULL,
 customer NUMBER(1) NOT NULL,
 originator NUMBER(1) NOT NULL,
 10 reporting_to NUMBER(1) NOT NULL,
 activity_members NUMBER(1) NOT NULL,
 date_updated DATE NOT NULL,
 primary key(id)
 15)

Records in this table contain the following data fields: (a) id: a unique ID in this table, (b) project_id: a specific Project ID, as notifications may be configured differently in different projects, (c) pr_activity_type: the ID of the record in PR_activity_type table 837 that represents the administrative activity type that the action represented by the record belongs to; (d) trigger_type: an indicator of when notification should be triggered, e.g., when the notification activity is posted as a scheduled activity to the PR_activity table 839 or when it is actually performed; (e) pr_owner: if the value equals one, the PR owner, i.e., the Assigned To person, should be notified, (f) customer: if the value equals one, the PR main contact should be notified, (g) originator: if the value equals one, the PR originator, e.g., the requestor, should be notified; (h) reporting_to: if the value equals one, the manager of the Assigned To person should be notified, (i) activity_members: if the value equals one, all members of the given activity should be notified; all of these persons are identified in a record associated with the PR record for which the activity is executed; and (j) date_updated: the date and time that this record was last updated.

AA_exec_report table 869

35 The actions represented by the records in this table generates a report concerning the PR records of the result set returned by the query which performs the activity to which the action belongs.

Records in table 869 have the following form:

```

AA_exec_report (
  id                NUMBER(12) NOT NULL,
  pr_activity_type  NUMBER(12) NOT NULL,
  report_template_id NUMBER(12) NOT NULL,
  filename_path     VARCHAR2(254),
  date_updated      DATE NOT NULL
)

```

- 10 The records in **AA_exec_report** table 869 represent actions that generate reports. A report is generated using a configured report template and includes all the PR records that were matched by the administrative query that resulted in the performance of the activity the action belongs to. The **AA_exec_report** table 869 contains the following data fields: (a) **id**: unique ID in this table, (b)
- 15 **pr_activity_type**: the ID of the record in **PR_activity_type** table 837 that represents the administrative activity type that the action represented by the record belongs to; (c) **report_template_id**: the id of a template for the report to be generated by the action; (d) **filename_path**: a complete filename and path specifying where the report should be saved -- this is not a mandatory field, and
- 20 if not specified, the report will be generated as a temporary file -- either the specified file or the temporary file is then sent electronically as an attachment to a specified list of recipients; and (e) **date_updated**: the date and time that this record was last updated. The list of recipients is in another table; the record for each recipient has a **pr_activity_type** value that specifies the record for the
- 25 administrative activity type that the action represented by the **AA_exec_report** record belongs to.

Details of the operation of system 801: FIGs. 1-4

- 30 *Overview of operation: FIG. 1.*

FIG. 1 is a high-level flowchart 101 of the operation of system 801. The first step (103) is configuring the system. The configuration process begins after a process that is to be monitored by system 801 has been designed. First, the persons doing the configuration design a PR record for the process, with the particular fields required to monitor the process. Once this is done, the persons

35 doing the configuration can configure the administrative queries that will do the actual monitoring. The administrative queries are configured by making or selecting records in administrative query tables 845 for the entire query (in **Admin_query** 853), for the SQL for the query (in **PR_query** 847), for the scope of the query (in **AQ_scope** 849), for the schedule for executing the query (in

40 **AQ_schedule_detail** 852), and for the administrative activities to be executed by the query (in **PR_activity_type** 837). The actions for each administrative activity

must further be defined in records in action tables 857. The PR_activity_type record for the initial administrative action for the query is specified in the query's record in Admin_query 853; this activity is performed whenever a PR record returned by the query is in the state of First Occurrence. PR_activity_type records for the activities that are performed when a PR record returned by the query is in the state of Persistent Conditions are specified in a program sequence for the query of Program_sequence records in table 855. It is an important advantage of system 801 that a query may be configured using records in PR_query table 847, AQ_scope table 849, AQ_schedule table 851, and Admin_activity_type table 841 that were created for other queries. This feature permits work that was previously done to configure another query to be reused in configuring a new query.

Once the process has been designed and records in the tables in DB system 825 have been properly configured, system 801 can begin executing administrative queries for the process. System 801 loads all the configuration information from administrative query tables 845, and Action tables 857 to construct current schedule table 823 and current query and processing plans table 824 in memory 809 of computer 803 in system 801; then selects the next administrative query to be executed from the current schedule table 823. Each time an administrative query is executed, system 801 uses the information for scheduling stored in current schedule table 823 for the query to specify the time of the query's next execution; each time this is done, system 801 finds the record in schedule table 823 that has the shortest time remaining until execution and executes the query when that time has expired, as shown in step 105.

If there is no query to be executed at the present time, system 801 takes branch 109 and checks whether any changes have been made in the configuration tables that define the processes and queries in DB system 825, namely: administrative query tables 845 and Action tables 857 (step 115); if there are no changes in the configuration, branch 107 is taken back to decision block 105; if there are any changes, branch 117 is taken and the updated configuration from the configuration tables in DB system 825 is fetched and the current schedule table 823 and the current query and processing plans table 824 are modified as required for such changes (step 119), and when that is done, system 801 returns to decision block 105 and again checks whether it is time to execute the next scheduled administrative query (loop 121).

If there is a query to be executed, system 801 executes the administrative query as it has been configured in tables 845 (block 113), as reflected in the current query and processing plans table 824: the query specified in the administrative query's PR_query record is executed on the PR records belonging to the scope specified in the query's AQ_scope record, and the activities specified in the administrative query itself and in its program sequence in Program_sequence 855 are performed. The activity performed for a given PR

record in the result set returned by an execution of an administrative query will depend on the record's state with regard to that execution; depending on the action records that belong to an administrative activity's Administrative activity type, performance of the administrative activity may modify the PR record, may
 5 post an activity in PR_activity table 839, may notify interested parties of something that has taken place in the process, may generate a report about the result set returned by the query, or may take action based on trends. When all of this is finished, system 801 updates the current schedule table 823 for the query just executed, setting the time for when this query will be executed next. Before
 10 executing the next query, 801 checks whether the configuration has changed (decision block 115); the possible results of such a check have already been described.

Details of configuring Administrative activity types: FIG. 2

15 An administrative activity type is configured by associating one or more actions defined in action tables 857 with the administrative activity type. In flowchart 201, the kinds of actions are represented by blocks in the flowchart. With regard to a given administrative activity type, there may be any number of actions associated with the given administrative activity type, the actions may be
 20 of any kind, and they may be configured in any order. An action defined by a given record in action tables 857 may, however, be associated with only a single administrative activity type.

Beginning with block 205, that block represents the configuration of notification actions represented by records in PR_notification table 867; block 207
 25 represents the configuration of actions that set values in PR records; these actions are represented by records in AA_set_values table 859, AA_set_dates table 861, and AA_set_person table 863. Block 209 represents the configuration of post activity actions represented by records in AA_post_activities table 865; Block 211, finally, represents actions represented by records in AA_exec_report 869.

30

Details of configuring administrative queries: FIG. 3

An administrative query is configured by associating an SQL query, a scope, a schedule, an Administrative activity type for the initial activity, a program sequence of Administrative activity types, a record in AQ_trends table
 35 879, and a priority with the administrative query. Previously existing SQL queries, scopes, schedules, and Administrative activity types may be reused in the configuration; the program sequence and the record in AQ_trends table 879 must be defined for the particular administrative query being configured. Flowchart 301 shows these operations; they may be performed in any order.

Beginning with block 305, that block sets forth the association of the SQL query with the administrative query; block 307 sets forth the association of the projects that define the administrative query's scope with the administrative query; block 309 sets forth the association of a schedule of execution with the query; block 310 sets forth the association of a record in AQ_trends table 879 with the administrative query; block 311 sets forth the association of the Administrative activity type for the query's initial administrative activity with the query; block 313 sets forth the association of a program sequence in Program_sequence table 855 with the query; block 315 sets forth the assignment of the query to a priority group.

Details of administrative query execution: FIG. 4

FIG. 4 is a more detailed flowchart 401 of blocks 105 and part of block 113 of FIG. 1. The part of the flowchart inside the dashed line represents block 105; the remainder represents block 113. Flowchart 401 shows how system 801 executes the code of execution module 821 of system 801 to execute an administrative query, performs activities associated with the query, and schedules the next execution of the administrative query.

Beginning with start block 403, as set forth there, flowchart 401 may be entered by the paths indicated by 103, 107, and 121 in FIG. 1. The first step is checking current schedule table 823 (block 407) for an administrative query that is scheduled to be executed at the current time; if none is found, it takes branch 409 from decision block 411 to decision block 115 in FIG. 1 to check if the configuration has changed. If there is an administrative query to execute at this time, it takes branch 413 to block 415.

The first step in that branch (block 415) is to execute the SQL query specified in the administrative query's record in Admin_query table 853, limiting the PR records the query is executed on to those specified in the projects specified in the administrative query's record scope. If the result set of PR records returned by the query is empty (decision block 417), branch 419 is taken: the execution of the query is logged in Admin_query_log table 873 (block 433) and system 801 uses the information contained in the schedule specified in the administrative query's record to update the administrative query's record in current schedule table 823 with the time of the next execution of the administrative query and returns to block 407.

If the result set is not empty, each PR record in the result set must be processed and system 801 begins executing loop 425, which gets executed once for every PR record in the result set. First, the next PR record in the result set is fetched (423); if there are no more PR records in the set (decision block 427), branch 429 is taken to branch 419, and processing continues as described above for that branch. If there is a PR record to process, branch 431 is taken to FIG. 5.

Since there may be multiple instances of system 801 running on database system 825, system 801 ensures that the instances have mutually exclusive access to the PR record being processed by attempting to lock each PR record it processes at the beginning of processing; if the attempt fails, the PR record is not processed as described below unless it is again returned by an administrative query. If the attempt succeeds, the PR record is processed and then unlocked when processing is finished.

Details of the processing of a PR record: FIG. 5

Processing of a PR record is shown at FIG. 5. As shown, block 537 determines the current record state; the next step (decision block 539) determines if the PR record is in the state of First Occurrence; if not, it is in the state of Persistent Conditions. As explained above, system 801 determines the state by examining the most recent execution record for the administrative query in Admin_query_log 873 and the most recent record for an execution of the administrative query with regard to the PR record in AQ_PR_log 875.

If the PR record is in the state of First Occurrence for that execution of the administrative query, system 801 takes branch 543 and performs the administrative activity whose Administrative activity type is specified in the field pr_activity_type of the administrative query's record in Admin_query table 853. That done, system 801 initializes the Next Sequence Pointer; in a preferred embodiment, it is initialized to 1 (545).

If the PR record is in the state of Persistent Conditions, system 801 takes branch 541. In that branch, it first evaluates the record in the administrative query's program sequence that is specified by the current value of the Next Sequence Pointer (block 551) to determine whether an administrative activity need be performed regarding the PR record on this execution of the query (decision block 555). If none need be performed, branch 558 is taken: a record for the current execution of the administrative query and the PR record is made in AQ_PR_log table 875, setting the date_aq_executed field to the date/time that the given administrative query was executed, and the next execution of loop 425 begins.

If the program sequence record specified by the current value of the Next Sequence Pointer indicates that the administrative activity specified in the program sequence record must be performed, system 801 takes branch 556; as set forth in block 549, system 801 performs the administrative activity and sets the value of the Next Sequence Pointer as indicated in the program sequence record. At this point, branch 543 and branch 556 come together; on both branches, the performed administrative activity is posted in PR_activity table 839 (block 557). Next, a record for the current execution of the administrative query, the PR record, and the performed administrative activity is made in AQ_PR_log table

875 (block 559), setting the following fields principal fields in AQ_PR_log table 875: admin_query_id, pr_id, date_aq_executed, date_aa_executed, and pr_activity_type; after this, the next execution of loop 425 begins.

5 Details of the GUI for defining and modifying administrative queries: FIGs. 9-17

As pointed out in the foregoing, system 801 is highly configurable but limits the configurability so that it can be safely done by non-technical users of system 801. One reason for this combination of configurability and safety is the fact that database tables are used to determine the behavior of system 801. Consequently, the data base system's tools can be used to configure the system, while the database system's access controls can be used to limit the degrees of configurability permitted to different users of the system. Another reason for the combination of configurability and safety in system 801 is the GUI which non-technical users of the system use to define and modify administrative queries. This GUI will be disclosed in detail in the following.

Defining administrative queries: FIGs. 9 and 17

As shown at 853 in FIG. 6, and explained in detail in the foregoing, an administrative query has a query, a scope of PR records 833 that the query will be performed on, a schedule indicating when it will be performed, and an administrative activity type that specifies one or more actions that will be taken on PR records 833 returned by an execution of the query. An administrative query may also have a program sequence 855 of administrative activities that are performed in various states of a given PR record with regard to executions of the query that return the PR record. Thus, in order to define an administrative query, one must either define its parts or choose already-defined parts. The same goes for modifications of existing administrative queries.

The top-level window of the GUI for defining or modifying administrative queries in a presently-preferred embodiment is shown at FIG. 9. Window 901 has a number of buttons which, when clicked on, give the user access to further windows for defining administrative queries and their parts. Thus, button 903 gives access to windows for defining the queries themselves, button 909 gives access to windows for defining administrative activities, button 907 gives access to windows for scheduling administrative queries, and button 911 gives access to windows for defining the scope of the administrative query.

FIG. 17 shows the window 1701 that appears when button 903 is clicked on. There is an entry 1702 in the window for each administrative query presently defined in system 801; each entry has six fields. Field 1703 contains the

name of the query executed by the administrative query; field 1705 contains the name of the initial administrative activity executed by the administrative query on PR records returned by the query; field 1707 contains the name of the administrative query's scope; field 1709 contains the name of the administrative query's schedule; field 1711 contains the administrative query's priority; field 1713, finally, indicates whether there is a program sequence associated with the administrative query, and if so, how many entries there are in the program sequence. With fields 1703 through 1709, the user may either type the requisite name into the field or type an *, at which point, a search window appears which permits the user to search for the desired component. The user may select an administrative query by selecting a row 1702. When a row is selected, button 1712 permits the user to insert a row for a new administrative query at that point in window 1701; button 1714 permits the user to delete one or more selected rows; button 1715 permits the user to view and modify a selected query's schedule; button 1717 permits the user to view and modify a selected query's scope; program button 1719, finally, permits the user to view and modify a selected administrative query's program sequence. Of course, not all users may have the access privileges necessary to use given ones of these buttons. The effect of defining a new administrative query, modifying an existing administrative query, or deleting an administrative query is of course to add a new record to admin_query table 853, modify an existing record in table 853, or delete a record from the table.

Window 1721 is the window that appears when the user clicks on program button 1719. Each row 1723 in window 1721 specifies an entry in the program sequence for the selected administrative query; the fields are the following: field 1725 specifies the sequence number of the program sequence entry ; field 1727 specifies the administrative activity to be performed; field 1729 specifies what to do after the administrative activity specified in the entry has been executed, and field 1731 specifies a time interval which must pass before the given entry should be considered. As already explained in detail in the discussion of program_sequence table 855 above, in the preferred embodiment there are three choices for program control: continue, i.e., continuing to perform the administrative activity specified in row 1723; next, i.e., performing the administrative activity with the next sequence number; and stop, i.e., performing no further administrative activities for the given administrative query. A user may of course use window 1721 to add, delete, or modify the program sequence; the changes made are retained in Program_sequence table 855.

40 *Defining scopes for administrative queries: FIG. 10*

FIG 10 shows the windows 1001 and 1009 involved in defining or modifying a scope. A given scope may of course be used in many administrative queries. Screen 1001 lists the presently-defined scopes. This window may be reached by clicking on scope button 1717 in window 1701 or clicking on scope button 911 in window 901. Each scope has an entry 1005 with the scope's name and the number of projects included in the scope. To define a new scope, the user clicks on the insert button and adds the scope's name to the list. To delete a scope, the user selects a scope and clicks on the delete button. To see or modify the projects in the scope, the user selects the scope and clicks on details button 1007; thereupon, window 1009 appears. Window 1009 has an entry 1010 for each project currently defined in project table 831. An entry 1010 has three fields: the division's name, specifying a record in Division table 829 (1011), the project's name, specifying a record table project table 831, and whether the project in the specific division is included in the scope selected in window 1001 (1013). A project may of course be added to or removed from the scope by clicking on the check box in field 1013 in the project's row 1010. Changes made in tables 1001 and 1009 are reflected in AQ_scope table 849 and in the scope specified in the administrative query's record in Admin_query 853. Note: the specific names given for records in the division table 829 and project table 831 is configurable as well; in the specific example of window 1009, a record in the division table 829 is named "Department", and a record in the project table is named "Record Type", another example would be "Location" and "Work Area", etc.

Defining schedules for administrative queries: FIG. 11

The graphical user interface employs windows 1101 and 1109 to define schedules for administrative queries. A given schedule may of course be used by many administrative queries. These windows are in general similar to those of FIG. 10. Window 1101 may be reached from schedule buttons 907 and 1715 in windows 901 and 1701. Window 1101 lists the existing schedules and permits the user to define new ones. Each row 1103 has two fields: field 1104, which contains the schedule's name, and field 1105, which indicates how many entries there are in the detailed description of the schedule. To define a new schedule, the user clicks on the insert button and inputs a name for the schedule into field 1104. To delete a schedule, the user selects a row 1103 and clicks on the delete button. To see the detail for a schedule, the user selects the schedule's entry 1103 and then clicks on details button 1107. Thereupon, window 1109 appears. Window 1109 has a row 1111 for each day of the week, and the user may specify for each day the start time and the end time for scheduling and the time interval between one execution of the query and the next. Changes made to windows 1101 and 1109 are preserved in AQ_schedule table 851, AQ_schedule_detail table 851, and in the relationship between an administrative query and an entry in AQ_schedule_table 851.

Defining administrative activities: FIG. 12

The graphical user interface employs the window 1201 shown in FIG. 12 to define administrative activities. Like scopes and schedules, a given administrative activity may be shared by many administrative queries. Window 1201 is reached by clicking on administrative activities button 909 in window 901. There is a row 1205 for each administrative activity defined in system 801. Each row has a field 1203 for the administrative activity's name and fields 1207 through 1213 indicating what kinds of actions the administrative activity has associated with it. If an administrative activity has a given kind of action associated with it, the box in the corresponding field of the administrative activity is checked, indicating this association. To clarify, if for example, the "Set Dates" and the "Posting Activities" check boxes for a given administrative activity are checked, it indicates that the given administrative activity has at least one action for setting date values, and at least one action for posting activities.

To define an administrative activity, the user clicks on the insert button and inputs the new administrative activity's name into the new row 1205. To define an action for the new administrative activity, the user clicks on one of buttons 1215 through 1221 as required for the kind of action being defined. If at least one action is defined in any of these action types, fields 1207 through 1213 will be checked, respectively. Similarly, if the user wishes to view or modify actions of a specific kind for a given administrative activity, the user selects the row 1205 for the administrative activity and then clicks on a button 1215 through 1221 as required for the kind of action. Deletion is done by selecting a row and then clicking on the delete button. The modifications made using window 1201 are preserved in admin_activity_type table 841.

General techniques used in defining actions

As indicated in the discussion of action tables 857 above, most actions involve changing one or more values of fields in the PR record upon which the action is performed. Such changes of course affect what queries will return the PR record, and thus move the PR record through the stages of a process that the PR record is an instance of. The manner in which the types of certain fields in the PR records are defined greatly increases the ease and safety with which actions may be defined and modified. Many of these types are defined by system 801; others may be defined by users. In both cases, the types are defined using the facilities which database system 825 provides for user-defined types.

Fields with values belonging to ordered sets of values

One way in which types of fields of PR records are defined is by defining an ordered set of values which fields of a type may have. For instance, a field in a PR record with the name `priority_type` may have a value from the ordered set of values {low, normal, emergency}. Because the set of values is ordered, it is possible to define operations such as incrementing a value in the set. If priority has been set to normal, then the result of the operation `increment(priority_type)` is emergency.

Another operation which is possible because a set of values is ordered, is selecting the members of the set in rotation. For example, a field in a PR record with the name `managers` may have as its values the names of the managers of the process being monitored, for example, {Brown, Gonzalez, Jones, Smith}. Here, a next operation may be used to rotate the assignment of tasks among the managers. With this operation, if `managers` has been set to Jones, then

```
managers := next(managers)
```

sets `managers` to Smith, and a repetition of the operation and assignment sets `managers` to Brown.

Role fields

In system 801, fields in a PR record whose values may be ordered lists of names of individuals are termed *role* fields. Roles and the rotation of tasks among the individuals belonging to a role are defined in system 801 by two tables in database system 825, the `Project_member` table and the `AA_role_last_used` table. The first of these tables defines membership of persons in projects and roles; the second keeps track of the last person belonging to a given role to have been given a task.

Project_member table

A record in `Project_member` table looks like this:

```
Project_member (
  id                NUMBER(12) NOT NULL,
  project_id        NUMBER(12) NOT NULL,
  person_rel_id     NUMBER(12) NOT NULL,
  person_role_type  NUMBER(6) NOT NULL,
  seq_no            NUMBER(6),
  date_updated      DATE NOT NULL,
  primary key(id)
)
```

Each record in the Project_member table represents a Project member, i.e., a specific person who is a member of a given Project. The Project_member table contains the following data fields: (a) id: a unique ID in this table; (b) person_rel_id: a unique ID of a given person; (c) person_role_type: a unique ID, specifying a given person role type, e.g., "Dispatcher", "Tier 1 Help Desk", and "Authorized Approver", (d) seq_no: a sequence number, which indicates the order in which project members with the SAME Person Role get selected (assigned), and (e) date_updated: the date and time that this record was last updated. The sequence number defines the order in the set of persons belonging to the role. A given individual may have more than one entry in the Project_member_table and thus belong to more than one project.

AA_role_last_used

A record in the AA_role_last_used table looks like this:

```

15  AA_role_last_used (
      id                NUMBER(12) NOT NULL,
      pr_activity_type  NUMBER(12) NOT NULL,
      data_field_id     NUMBER(12) NOT NULL,
      person_role_type  NUMBER(6) NOT NULL,
20  person_rel_id       NUMBER(12) NOT NULL,
      seq_no            NUMBER(6),
      date_updated      DATE NOT NULL
  )

```

Each record in the AA_role_last_used table is associated with a given administrative activity and logs a person ID and a corresponding sequence number which were last used for a given Admin Activity to assign a person belonging to the role to a given PR data field. The AA_role_last_used table contains the following data fields: (a) id: a unique ID in this table; (b) pr_activity_type: an identifier of a record in PR_activity_type table 837 that represents the activity's PR_activity type; (c) data_field_id: a value that specifies what field was set with the last execution of the given Admin Activity; (d) person_role_type: identifying the person role that was last used when setting the given data field, (e) seq_no: identifying a sequence number that was last used when setting the given data field, and (f) date_updated: the date and time that this record was last updated.

Null values for fields

Fields in PR records may have null values, which makes it possible for an action to determine whether a previous action has set the field's value and to respond accordingly.

Using values from other fields in the PR records in setting fields

In many cases, an action sets a given field in a PR record using a value from another field in the PR record. The field from which the value being used comes is called the *reference* field. The value may be simply copied, but generally, an operation is applied to the value and the value as modified by the operation is then assigned to the given field in the PR record. For example, if the value is one of an ordered set of values, the value from the reference field may be incremented before it is assigned to the other field.

The graphical user interfaces for defining actions in a preferred embodiment of system 801 take advantage of all of these characteristics of the fields in PR records to simplify the task of defining actions. In the following, the manner in which each type of action is defined will be described in turn.

Defining AA_set_value actions: FIG. 13

FIG. 13 shows the graphical user interface for defining an AA_set_value action in system 801. These actions set fields in PR records whose values neither represent times or dates nor represent persons or roles. The fields' types may be defined by system 801 or users of system 801, but the values for each type must constitute an ordered set. An example of such a field is a priority field for which the values may be {low, normal, emergency}. Window 1301 contains a list of fields in PR records in system 801 that may be set by AA_set_value actions. The entry 1302 for each field has the field's name (1303), its type (1305), i.e., whether its values may belong to a single type or to more than one type, the operation to be performed on the field's value (1307), which is one of set, increment, or clear, as shown by the drop-down menu at 1311, and the value to which the field is to be set (1309), if the set operation is specified. Row 1302 thus specifies the set value action as setting the value of the field priority to Emergency. The detail of window 1301 at 1310 shows how the user may see the available operations by clicking on field 1307 in entry 1302 to get drop-down menu 1311, from which the user can select the desired operation. The detail at 1313 shows the window showing the possible values of the field priority which appears when the user clicks on field 1309 in row 1302. The user may select one of the values in the window. Creation or modification of an AA_set_value action in window 1301 of course results in the creation or modification of a record in AA_set_values table 859. As shown by this interface, system 801 separates definition of PR records from definition of operations on PR records.

General characteristics of windows that define actions

FIG. 13 also shows a number of general characteristics of the windows that are used to define actions in a preferred embodiment. There is a window for each kind of action, and each window contains a table which has an entry for every field in any of the PR records defined in system 801 which can be set by the kind of action that the window defines. An entry has two parts: the first part, 303, is a field which identifies the field in the PR record which will be affected by the action. The second part 1306 is one or more fields that define the action to be taken on the field identified by field 1303. What fields are in 1306 and how they define the action depend on the kind of action, or put another way, on the type of the values which field 1303 may contain.

When a user selects an administrative activity by selecting a row 1205 in FIG. 12 and then clicks on one of the buttons 1215 through 1221, the resulting window displays all of the actions of the type specified by the button which have been defined for the selected administrative activity. If an action has been defined for the administrative activity for a given field, the fields 1306 in the given field's entry contain the specification of the action. If there is no specification, no action has been specified. To specify or modify an action for a given field, one simply specifies or modifies the fields 1306 in the given field's entry as required.

Defining an AA_set_dates action: FIG. 14

Window 1401 appears when a user clicks on date values button 1217 in window 1201. Window 1401 has a row 1402 for each time-date field which can be set by a set dates action in any PR record. The row has eight fields: field 1403 which specifies the name of the field to be set; fields 1405-1409, which specify how the field is to be set if it has a null value at the time the action is performed; and fields 1411-1413, which specify how the field is to be set if it does not have a null value at that time. Time-date fields are set by specifying a reference field, which is another time-date field in the PR record the action is being performed on, and an operation to be performed on the time-date field. Taking fields 1405-1409 for the case when the field being set has a null value as an example, field 1405 specifies the name of the reference field; as shown in the detail at 1414, it may be set from a drop-down menu 1417 which becomes visible when the user clicks on field 1405. The reference fields also include a built-in system reference field whose value is always the current time when the action is being taken. The fields 1407 and 1409 define the manner in which the time-date value from the reference field is to be modified to make the value which the field to be set is to receive. Field 1407 indicates the value to be added or subtracted from the value of the reference field and field 1409 specifies the time units, i.e., hours, minutes, days, weeks, as shown at 1423 in detail 1422. As shown at 1423, the time units

may be selected from a drop-down menu. Also shown in detail 1422 is days rule field 1412, which indicates whether the time is to be calculated in terms of business days or calendar days.

5 Row 1424 in detail 1422 shows a complete definition of how an AA_set_dates action is to set a date: the date due field is to be set when it has a null value by using the date created field as a reference field and adding 30 calendar days to it, as specified in drop-down menu 1423 and at 1425. As is
10 apparent from window 1401, setting a field that is already set when an action occurs may be done by setting fields 1411 and 1413 as just described for fields 1403-1409. If an action needs to respond both to a null value and to a non-null value in the field being set, values to which the field is to be set may be specified for both the null value and the non-null value cases. The AA_set_dates action defined in window 1401 is of course preserved by adding a record to or
15 modifying an existing record in AA_set_dates table 861.

Defining an AA_set_person action: FIG. 15

Window 1501 is the window that appears when a user clicks on person values button 1219. Each row 1513 in window 1501 represents a PR field whose
20 value is either null or a value representing a given person. As with window 1301, there is a field for the name of the PR field being set (1503) and then two sets of fields: one, fields 1505 and 1507, for the case where the field being set has a null value at the time the activity is performed, and the other, fields 1509 and 1511 for the case where the field being set does not have a null value. Again,
25 both sets of fields may be defined for a single set_person action. In both sets of fields, one of the fields (1505, 1509) permits the field to be set directly to a value which represents a given person or from a reference field whose value represents a given person, while the other of the fields (1507, 1511) permits the field to be set using a value representing the next person specified for a given role at the time
30 the action is performed. As shown at 1515, a role may be selected from a list of roles that have been defined in system 801. A direct specification of a person's name is shown at 1517; if the user enters a * in either field 1505 or 1509, a list of the people who are known to system 801 appears and the user may select a name from the list; if the user clicks on either field 1505 or 1507, a drop-down menu of
35 reference fields appears. Results of the action definition or modification made using window 1501 are of course retained in an entry in AA_set_person field 863.

Defining an AA_post_activities action: FIG. 16

When a user clicks on activities button 1221 of FIG. 12, window 1601
40 appears. In this window, the user can define an AA_post_activities action. The

result of such an action is not the modification of a PR record returned by the administrative query, but rather the posting of a record in PR_activity table 839 indicating an activity performed automatically, as a consequence of performing the given administrative activity or an activity which is automatically scheduled to be performed by a given person. The record in this table simply indicates whether the activity is to be performed or scheduled to be performed.

There is a row 1602 in window 1601 for each non-administrative PR_activity_type in PR_activity_type table 837. The name of the activity appears in field 1604; field 1603 specifies the posting mode, i.e., whether the record indicates simply that the activity is to be performed, or whether it is scheduled. If the user clicks on field 1603, a drop down menu with the possibilities appears. If the user selects the *scheduled* posting mode, fields 1605 through 1607 are used to specify the scheduled time in the same fashion as was explained with regard to fields 1405 through 1409 of FIG. 14. Field 1605 specifies the field in the PR record which is to be used as the reference field to compute the schedule; the fields labeled by 1607 indicate how the scheduled date is to be computed. Fields 1609 and 1611 offer two mutually-exclusive ways of specifying the person to perform the activity. Field 1609 specifies it by using a reference field with a person value in the PR record; the reference field may of course have a role type, with the value of the person being that currently specified for the role. Field 1611 specifies the person directly; in both cases, drop-down lists provide possibilities the user can choose from. When system 801 processes a PR record returned by an administrative query, it selects person values for fields of the role type before it does any other processing; system 801 thus guarantees that the tasks being posted by AA_post_activities actions will be evenly distributed among the persons who are to do them. An entry 1602 for a completely-defined AA_post_activity is shown at 1613. The activity is Begin Audit, which is a scheduled activity that is to be performed within two days of the date-time at which the administrative activity that performs the action is executed, using calendar reckoning. The audit is to be done by the person specified by the value of the field "Contact" in the PR record with regard to which the action was performed at the time the action was performed. The date reference field specified at 1614 for this example is the built-in system date reference field discussed with regard to set date actions. When a post activity action is defined or modified using window, the defined or modified action is preserved in AA_post_activities table 865. Another example would be "Ship Order", an activity to be performed 2 days after an order has been received, using a "Date Received Order" PR field as a reference, instead of the system date reference used in the previous example.

Using a reference date and or date/time provides ease of configuration and the flexibility to configure system 801 to perform applicable activities based

on any administrative query criteria, and based as well as on any relevant PR data fields.

Dynamic behavior of system 801

5 An important characteristic of system 801 is that it does not statically define the manner in which it monitors a process. Instead, it is able to dynamically adapt the manner in which it monitors the process to events that occur in the course of the process. One aspect of system 801's dynamic adaptability is its recognition of the states of First Occurrence and Persistent
10 Conditions; another is its ability to define substates of a persistent condition and vary the manner in which the process is monitored according to the substate. Other aspects of system 801's dynamic adaptability are its use of a reference field in a PR record to obtain a value which can be used in original or modified form to set another field in the PR record, its use of types defined as ordered sets of
15 values to define escalation operations and to distribute tasks evenly among those responsible for them, and its ability to define actions on the basis of whether a field has already had a value assigned to it. This adaptability is coupled with a graphical user interface which defines an action on the basis of the type of field the action applies to and can thus structure the window in which the action is
20 defined so that the user can easily specify the actions that are relevant to the type of the field the action applies to. With this graphical user interface, a non-technical user of system 101 can easily and safely take full advantage of the adaptability.

25

Conclusion

30 The foregoing *Detailed Description* has disclosed to those skilled in the relevant arts how to make and use a process control system that automatically provides as much monitoring as is desirable for the processes being controlled and has disclosed to those skilled in the relevant arts the best mode presently known by the inventors for implementing their process control system. The
35 information needed to do the monitoring, including the queries that perform the monitoring and the activities to be performed in response to conditions detected by the queries, is all contained in tables in a database system. The fact that the information is contained in the database tables makes the process control system easily and safely configurable and extendable. The ease and safety of

configurability is further enhanced by the graphical user interface disclosed herein.

5 It will be immediately apparent to those skilled in the relevant arts that there are many other ways of implementing the process control system. In particular, there are many ways in which the information needed to do the monitoring can be represented in the database system. Moreover, the information needed and the manner in which the process control system operates will both vary with the kind of process being monitored; in the preferred embodiment, the processes being monitored are business processes; 10 other embodiments may monitor physical processes and the information in the database system, the manner in which it is organized, and the manner in which it is used to do the monitoring will all vary accordingly.

15 The same is the case with regard to the graphical user interface. There are many ways in which graphical user interfaces that embody the principles of the inventions claimed herein can be implemented; How they look and work in detail will depend not only on the purpose for which the process control system is being used but also on the underlying graphical user interface tools and primitives provided by the system upon which the graphical user interface is 20 implemented. Moreover, there are many other ways in which the principles of the inventions disclosed herein can be employed. For example, the technique of the role field can be used in any case where there is an ordered set of values, as can the technique of the increment operation, and reference fields will work as sources of values for any kind of field that is being acted on. Detailed operations and the details of how they are specified will of course also depend on the kinds 25 of values which the field being acted on may have.

30 Since that is the case, the *Detailed Description* is to be regarded as being in all respects exemplary and not restrictive, and the breadth of the invention disclosed herein is to be determined not from the Detailed Description, but rather from the claims as interpreted with the full breadth permitted by the patent laws.

What is claimed is: